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SUPPLEMENT TO REPORT NO. 25X1

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The activities of the deported German engineers from the Junkers and BMW plants at Opytnyy Zavod No. 2 (Experimental Plant No. 2) in Upravlencheskiy-Gorodok (53-12N, 50-09E) included the duplication or improvement of turbojet engines BMW-003, JUMO-004, and JUMO-012, and turboprop engine JUMO-022.

BMW-003 C

1. The development of the BMW-003 C was completed in about mid-1947 when the engine was subjected to the State test. The structural setup of the engine remained unchanged. With the maximum revolution speed being 11,000 rpm, the specific fuel consumption was 1.32 kg/kgp/h, and the air throughput was 18 kg/sec. A static thrust of 1,050 kgp was achieved. Source believed that the BMW-003 was in mass production in Kazan. This assumption was supported by the fact that the two BMW experts, Engineer Karl Schenke and Engineer Simon (fnu), visited Kazan in 1947 to eliminate difficulties with governors in mass production. Both engineers stated that the plant in Kazan was well equipped.[1]

JUMO-004 B

2. Of the many versions of the JUMO-004, only the JUMO-004 B was being worked on at the plant. The power unit was equipped with two additional combustion chambers. The fuel consumption was reduced from 1.43 kg/kgp/h to between 1.32 and 1.34 kg/kgp/h. The output of the engine was rated at 900 kg, the static thrust at 8,700 rpm maximum, and the engine had a compression ratio between 2.9 to 1 and 3.2 to 1. The pressure aft of the turbine was 1.5 kg/sq cm; the gas temperature aft of the turbine was 620 to 640 degrees centigrade, and the temperature in the exhaust unit was 590 to 610° centigrade.

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Fuel was injected with a pressure of 55 kg/sq cm. The oil consumption was one liter per hour and the air throughput 21 to 23 kg/sec. The over-all length of the power unit was 3,900 mm; its maximum diameter was 810 mm, and the weight was 710 kg. The basic structural setup of the engine was not changed. Source believed that the JUMO-004 was produced in Ufa/Chernikovka. Engineer Friedrich Kreuzburg briefly visited that plant to eliminate difficulties with the governors which occurred there as in Kazan. By late 1947, the JUMO-004 project was completed at OPN 2.[2]

JUMO-012

3. In about mid-1948, the JUMO-012 was ready for mass production. On Soviet requests, the JUMO-012 was designed with an output of 3,000 kgp at a fuel consumption of 1.1 kg/kgp/h and a weight of 1,600 kg. The following data based on the INA (International Standard Atmospheres) were actually achieved with the power unit. The engine had a thrust of 3,000 kg at a starting speed of 6,200 rpm; it rated at 5,900 rpm cruising speed and at 5,700 rpm economical speed. The fuel consumption was 1.09 kg/kgp/h for a static thrust at sea level. The reduced weight of 1,480 kg was achieved by boring holes in the turbine discs. The compression ratio was 4.2 to 1, and the air throughput was 59 to 60 kg/sec. The gas temperature forward of the turbine was calculated at 850 degrees centigrade. The specific weight amounted to 0.493 kg. The power unit had an over-all length of 5,000 mm to 5,500 mm and a maximum diameter of 1,150mm. The JUMO-012 was fitted with a 12-stage axial compressor, 12 individual burner cans which ended in one annular combustion chamber, and a two-stage turbine. The exhaust cone was rigged. When accelerating the engine, air was released between the fourth and fifth compressor stages with the engine running at 3,500 to 5,400 rpm.[3] An increased output, to be achieved by after-burning of the water injection, was not planned. However, Dr. Manfred Christian was requested to start research in the field of after-burning according to the constant volume system. German material was used for the blades of the first power units constructed at the plant. Difficulties occurring with the less heat-resistant Soviet material were eliminated by fine grain forging at OPN 2. Source believed that the poor processing and tooling of the blades rather than the lack of suitable alloys were responsible for this failure. American blade material which was once supplied to the plant proved to be good but was no longer available.[4]

4. Source believed that the JUMO-012 was produced in Kazan, an assumption which was supported by the fact that Soviet engineers from Kazan came to ask the advice of Physicist Guenther Hermann on blade oscillations. The blades were ones from the JUMO-012. [redacted] [redacted]

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JUMO-022 Turboprop Engine

5. The JUMO-022 was almost completed by October 1950. At that time its most essential data, according to the INA system, included 4,500 shaft hp and an additional thrust of 600 kg. With a reduction factor of 0.91 the actual shaft output would be 5,000 hp. Theoretically, 5,500 to 6,000 hp could have been achieved easily by increasing the combustion temperatures to the ones of the JUMO-012.[6] However, this power could not be utilized because of the poor propeller gearing. In mid-1950, a new gear suitable for 6,500 hp was being constructed. The engine had a 7,500 rpm take-off speed, 7,250 rpm cruising speed, and 7,125 rpm economical speed. The weight, including two three bladed counter rotating propellers, 4.5 m in diameter, was 1,800 to 1,900 kg. One propeller consumed 57 percent of the power, while the other one was driven by the remaining 43 percent, due to the design of the planetary gear, which was driving one propeller from the external periphery of the sun-wheel while the other propeller shaft ended at its internal periphery. The engine was designed with a compression ratio of 5.2 to 1; the measured data ranged between 4.7 to 1 and 4.8 to 1. The air throughput was to be 32 kg/sec, but only 29 to 30 kg/sec could be achieved. The gas temperature forward of the turbine was about 790 degrees centigrade and the specific weight (weight per hp) was

0.360 kg. It was not planned to increase the output of the engine by installing an after-burner, etc. The power unit was essentially a pantographically scaled down version of the JUMO-012; it had a 14-stage compressor, the same combustion unit with 12 cans and a three-stage turbine. When accelerating the engine, the compressor released air between the fourth and fifth compressor stage with the engine running at 3,500 to 5,400 rpm. The exhaust speed in the jet unit was 170 to 180 m/sec. The transmission gear ratio to the turbine was 1 to 6.4.[7]

6. The JUMO-022 was designed with a combined governor system. The amount of fuel to be supplied was synchronized to the temperatures forward of the turbine which, independent from the external atmospheric pressure, were kept constant to each of the various output ratings. For n-7,500 the temperature upstream of the turbine was 1,060 centigrades k (absolute temperature Kelvin scale) and for n-7,150 the temperature was 890 centigrades (Kelvin scale), etc. The air volume and the momentary specific weight of the air had to be measured in order to feed the correct amount of fuel in accordance with these data. The air volume was set by the various delivery rates of the compressor. In order to control the specific weight of air, the pressure and the temperature had to be measured continuously and coordinated. The pressure was regulated by a barometric cell and the temperature by a temperature regulator. The fuel flow was controlled as follows: the section of the fuel flow passage could be enlarged or reduced by two adjustable cylinders, one inside the other, by turning one of them on the axis. Thus, the amount of fuel was supplied which was required to obtain a certain number of rpm. The revolutions of the propellers were regulated simultaneously with the rpm by means of two centrifugal governors. The flow section was also varied axially by the momentary external pressure of the compressor and the external temperature forward of the compressor. If there was an increase of external pressure at an unchanged (constant) temperature, the fuel passage was enlarged by means of the lever transmission. In coordination between pressure and temperature, the influence of the temperature operated the lever and thus affected the correct amount of fuel to be fed. This fuel governor system was coordinated with the propeller governor (rpm governor) through a cam transmission. The power output limitation was installed to protect the engine or the gearing from excessive operation at very low external temperatures and high external pressures as well as at low altitudes. The maximum amount of fuel required for the maximum rating was limited and could not be exceeded. This limitation would cause losses of power at high speed, low altitude flights; however, because of the degree of the limit, the losses could soon be overcome when the aircraft gained altitude. This power limitation was a compromise solution which could have been omitted by the installation of gears of adequate size.[8]

7. Source believed that the JUMO-022 was produced in Kuybyshev/Bezymyanka, since Experimental Plant No. 2 was constantly in connection with Bezymyanka and because 12 to 15 Soviets from Bezymyanka came to work at various places at Plant No. 2 in 1950, obviously to familiarize themselves with this type of work. Work on the JUMO-012 was completed at that time. Source noticed another indication that the JUMO-022 was produced in Bezymyanka. One JUMO-022 engine, merely covered by a tarpaulin, was loaded on a truck not belonging to Plant No. 2 and shipped to a place which presumably was located in Krasnaya Glinka, several kilometers away. If the power unit was to be shipped to a distant place it would have been packed in a crate and shipped to Krasanya Glinka railroad station by a plant-owned truck. It was known that the plant director in Bezymyanka constantly tried to have Plant No. 2 annexed to Bezymyanka. This was confirmed by young Soviet engineers from Bezymyanka.

8. [redacted] As far as this was possible at Zavod No. 2, all data on the further course of development and testing were forwarded to his department. The engines were started with compressed air at Zavod No. 2. A turbo starter unit of the TS-1 type was constructed for the JUMO-012 and a TS-2 turbo starter with about 100 hp was ordered for the JUMO-022.[10] It was difficult to determine the life of the JUMO engines 012 and 022. Many JUMO-012s ran much longer than 100 hours, and a JUMO-022 ran more than 500 hours without any difficulties. Failures at the test stands were generally caused by the blades which turned loose and by the burning of the slot mixers at the combustion chambers. The JUMO-022 was subjected to eight to ten official test runs, the records of which were forwarded to the Soviet chief engineer for the installation of engines in airframes at Zavod No. 1 in Podberezhe and to another unidentified plant. Both plants in turn transmitted various requirements, which generally could be met without difficulties.

General Information

9. The test stand for the JUMO-012 was equipped with a thrust scale similar to the one used with the JUMO-004. Zavod No. 2 constructed a great number of thrust scales for the JUMO-004 and shipped them to Leningrad. Source learned from the Soviets that a turbojet engine with radial-flow compressor was mass produced in Leningrad. From Soviet statements, the German engineers concluded that a version of the Nene engine was referred to. Klimov (fnu), the director of the Leningrad plant, briefly visited Zavod No. 2

10. The development activites were seriously hampered by the primitive way of testing compressors, turbines, and combustion chambers. The quality of the raw material and of semi-finished products differed widely. It was, therefore, required that each individual piece be checked in the material testing department. The delivery tags usually gave entirely incorrect data on the material. The quality of the casts, especially those of duraluminum supplied from other plants, was so poor that casting was started on a large scale at OPN 2.

11. Kerosene was used as fuel. The calorific power measured varied between 10,300 and 10,500 caloric units. The average heat value can be assumed to be 10,500 caloric units. The kerosene was of a yellow-red-brown color but was still transparent.

12. Zavod No. 2 also worked on a project designated GT-3, which was a stationary gas turbine with an output of 30,000 hp.

25X1 [redacted] Comments

1. The static thrust of the improved BMW-003 C was previously given at 1,250 kgp; [redacted] A thrust of 1,050 kgp seems to be more probable. During a previous stage of development in Germany the output was already increased from 800 to 900 kgp.

25X1

2. Compared with the increased thrust of 1,500 kgp as previously reported, the thrust increase with the standard JUMO-004 from 860 to 900 kgp seems to be rather low. Source explained that this was due to the characteristics of the compressor, the maximum performance curve of which was reached at the stage of planning. Any further attempts to improve the compressor rating would have led to an absurd increase of fuel consumption without gaining any additional thrust. This opinion of source is correct with regard to the JUMO-004 B. The JUMO-004 H, a pantographically scaled down version of the JUMO-012, was designed with a static thrust of 1,800 kgp. The engine was constructed at the end of the war and was further developed in the USSR.

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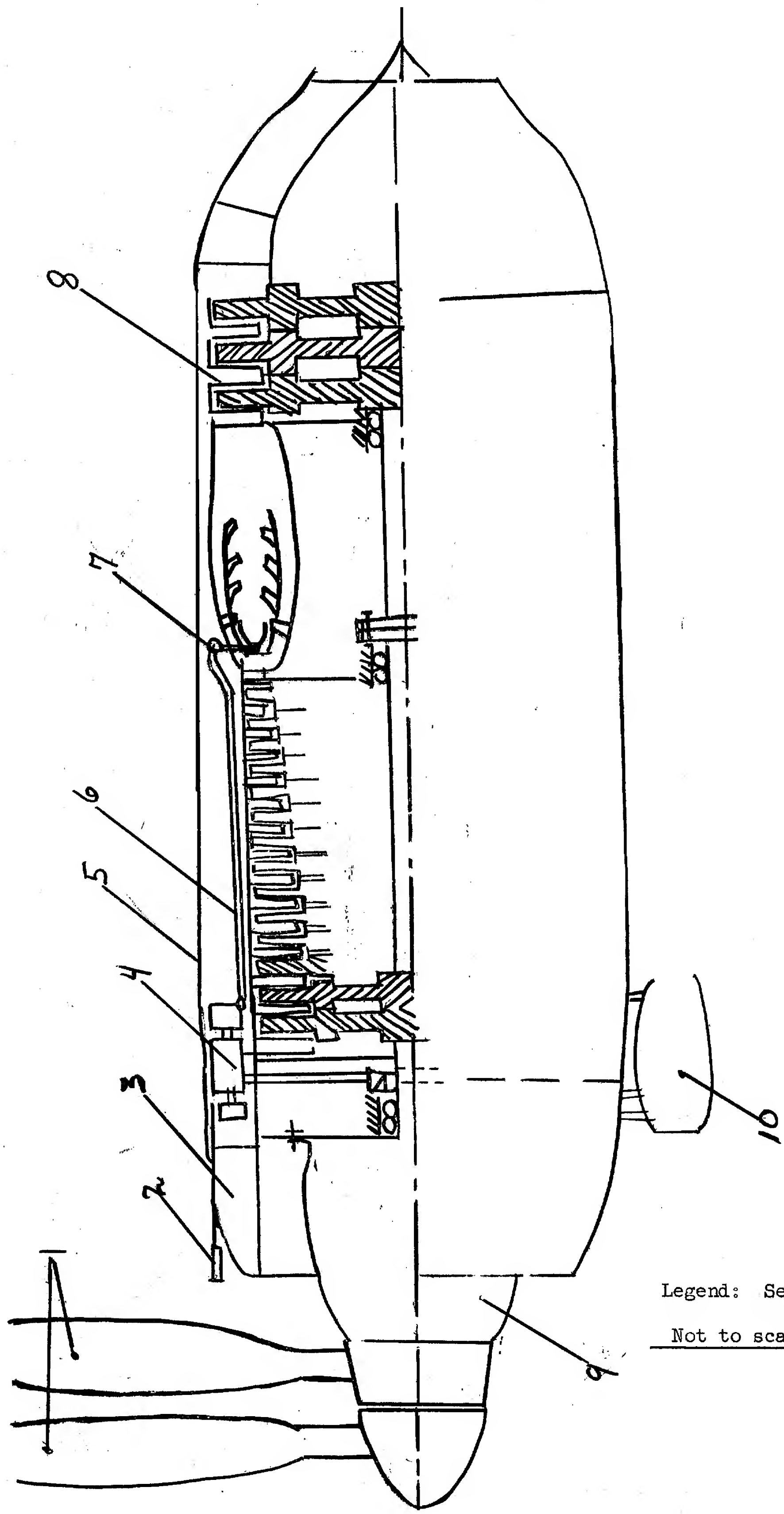
Attachment 1

The JUMO-022 Turboprop Engine Developed at Zavod No. 2 in Upravlencheskiy Gorodok



Legend: See next page.

Not to scale

Legend

1 Counterrotating propellers.

2 Temperature regulator (T_1).

3 Air inlet cowling.

4 Accessory section with pumps, governors, and generators.

5 Cowling.

6 Stator blades.

7 Annular fuel line leading to all injection nozzles.

8 Stator blades.

9 Gearing with a transmission ratio of 1 to 6.4.

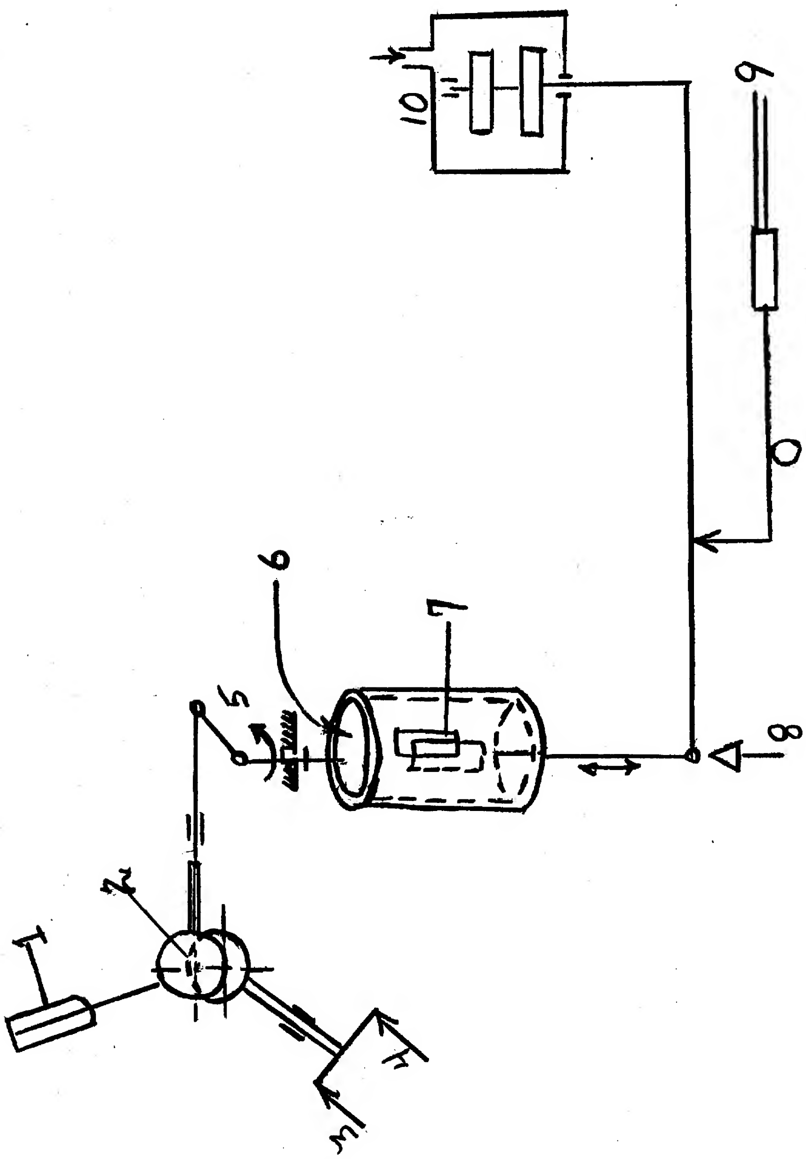
10 Preliminary installation of TS-1 starter unit.

The compressor and gear castings were light metal castings. The stator blades for compressor and turbine, the combustion chambers, and the exhaust unit were welded. The internal part of the combustion chamber with the slot mixers was insertable as a ring. The bearings are merely indicated on the sketch. The gears were flanged to the front reenforcing ribs.

[redacted] 25X1

Attachment 2

Governor System of the JUMO-022 Turboprop Engine Developed at Zavod No. 2 in Upravlencheskiy Gorodok



Legend

1. Control lever.
2. Eccentric cams.
3. Propeller governor I.
4. Propeller governor II.
5. Connecting joint.
6. Fuel flow from the pumps.
7. Flow section control at fuel line leading to the nozzles.
8. Adjustable power limitation.
9. Temperature meter thermometer.
10. Pressure gauge.

3. With the compressor being projected for constant pressure, the great amount of air (pressure at sea level) was released and utilized to cool the turbine.

4. Heat resistance cannot be achieved by fine grain forging, as it is generally a matter of proper alloys.

5. Physicist Guenther Hermann was a testing expert for materials in Krasnaya Glinka.

6. With this reduction factor, which was chosen by the Ministry for Aviation Industry, it was possible to achieve the projected shaft hp even at an unfavorable propeller efficiency.

7. For a schematic reproduction of the JUMO-022, see Attachment No. 1. Another source reported the JUMO-012 with 16 burner cans [redacted] 25X1

8. For schematical reproduction of the JUMO-022 governor system, see Attachment No. 2. 25X1

[redacted]

25X1 [redacted] Comment.

25X1 10. [redacted] for reports on TS turbojet starter engine development at Zavod No. 2.

Attachments: Two

1. Sketch of the JUMO-022 turboprop engine. 25X1

2. Sketch of the governor system of the JUMO-022.